EXPERIENCE WITH SITE SCREENING AND SELECTION FOR CO2 STORAGE

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Summary

- Storage of CO_2 from large emitters can be an attractive method for greenhouse gas management.
- Site selection for CO_2 storage is constrained by the volume of CO_2 to be stored, policy and regulatory requirements, ownership or concession interests, economic viability, and operational and monitoring issues.
- The process to identify a short list portfolio of storage sites is based on currently available technology. A typical workflow is as follows:
  - Assess EOR and other usage options in the region.
  - Identify regional seals in the stratigraphic column
  - Identify potential aquifer storage sites
  - Assess storage site characteristics against project requirements and constraints
  - Determine economic characteristics of the potential sites
  - Estimate the remaining work to be done and the cost for that work in order to bring the sites to the decision point for final choice and regulatory approval
  - Ensure, to the extent possible, that the site and storage process will qualify for whatever credits and financial incentives that may be available

The Problem

Highlight what experience with large volume injection projects in Canada and Australia has shown about the issues surrounding storage projects dealing with large sources of CO_2.

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Your assignment:

"Find a geological storage solution for 220 MMSCFPD over 20+ years and a total of 2 TCF of CO_2"

(GEODISC base case)

What are the rules?

Rules and guidelines for developing CO2 storage options come in at least three basic forms:

1. Technical constraints
2. Regulatory guidance
3. Economic realities

Technical Constraints

The storage site must be:

•at least ~800m deep (CO_2 dense phase)

•contained by a seal

•at a relatively low fluid pressure, i.e. not over-pressured, to keep compression requirements down

•able to take required injection rates and large volumes without fracture/containment risk

•stable in the sense that the predicted CO_2 movement will not take it to any sensitive locations

Regulatory guidance

- Project must be safe
- Project must be environmentally effective – benefits outweigh the costs (dollars, land use, additional emissions, risks, etc)
- Should not negatively impact other economic operations in the area, e.g. oil, gas and mineral extraction, freshwater aquifer usage.
- Must follow existing regulations that pertain to similar injection projects. Expect more CO_2 specific regulations in the near future
- Follow rules as they are developed in order to earn credits for CO_2 storage

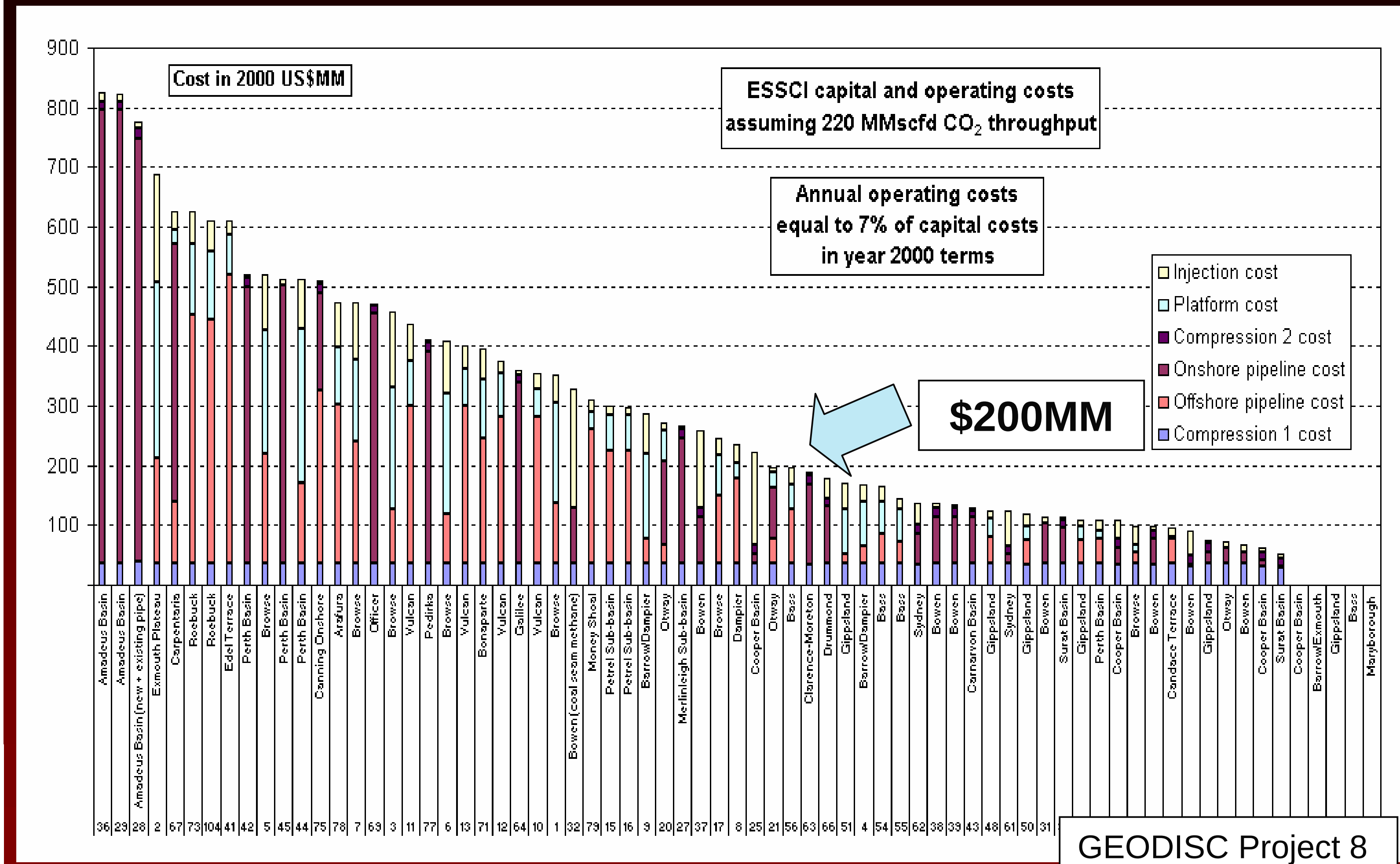
Economic realities

Once the CO_2 has been captured, it has to be transported, injected and stored in order to earn credits or effect enhanced recovery (EOR/EGR)

- An option with an economic benefit (income/tax offset) is preferred, if available
- Pipelines are expensive
- Compression is expensive
- Wells can be expensive

Economic realities

CO2 storage has large costs that are all up front



Economic realities

- Large up-front costs limit the number of companies and government organizations that can undertake major storage projects
- An income stream and/or tax regime that benefits storage can mitigate this to some extent

Economic realities lead to the first conclusion. . .

EOR is the favored option

EOR has the advantages of

1. Revenue for all parties
2. Known seals
3. Fields often have pressure depletion
4. Fields definitely have fluid production
5. Some infrastructure is in place that could be used or adapted

EOR is great if it is available, but...

EOR issues

EOR as a solution can be limited by many issues such as:

1. Few single fields are large enough to take all the CO_2 from a large source. Thus, many fields must be available, and the infrastructure must be put in place for each
2. EOR opportunities are often not close to the CO_2 source
3. Not all fields are suitable for EOR
4. EOR is very capital intensive, only the biggest companies can consider large scale EOR projects without subsidies
5. The life of an EOR project may not match the life of the source, meaning that even more facilities would have to be built later in the project life
6. EOR projects deal with large numbers of wells, which are the most likely leak points.
7. Existing infrastructure may need expensive retrofitting
8. CO_2 is a purchased asset in current EOR projects, owners have incentive to reuse it rather than leave it in the ground

What to do when EOR is not possible

If EOR options are not available, then the search focuses on:

1. Depleted or nearly depleted fields
2. Aquifers

Depleted fields have most of the shortcomings of EOR options, e.g. few fields are of appropriate size. Several to many would need to be used to handle CO2 from large sources. Also, high oil and gas prices delay abandonment of fields.

Aquifers have the potential for storage of very large volumes, if conditions are right

Saline aquifer injection – additional considerations

1. Aquifer pore volume >> CO_2 injected volume ~infinite acting reservoir in order to avoid significant pressure increases.
2. If the pore volume isn't large enough there must be, or must have been, fluid withdrawal from oil, gas or water production that offsets the injection
3. A suitable storage configuration for most of the CO_2 as a separate phase must be found. The ultimate disposition of most CO_2 will be in solution, but it may not get there for quite a while.

Looking for aquifer options

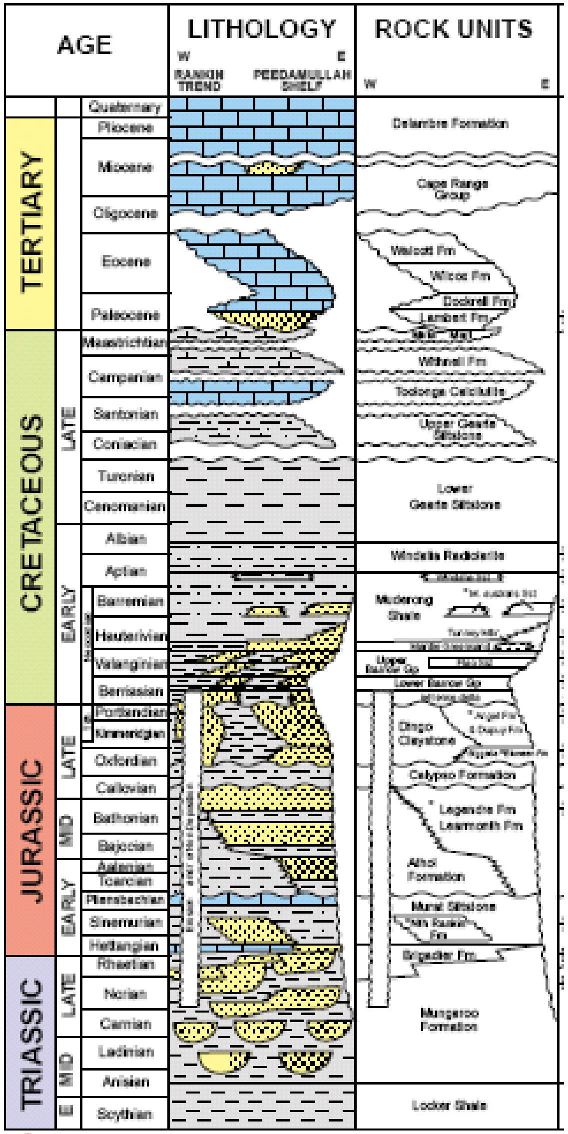
- Identify likely seals

- Regional seals are effective over a significant area of a basin. Commonly, these are evaporites or deepwater shales

- Subregional shales are effective over regions within a basin

- Sealing shown by effects on hydrocarbon accumulations, pressures, salinities, etc

Northern Carnarvon Basin, Australia



Regional Seals

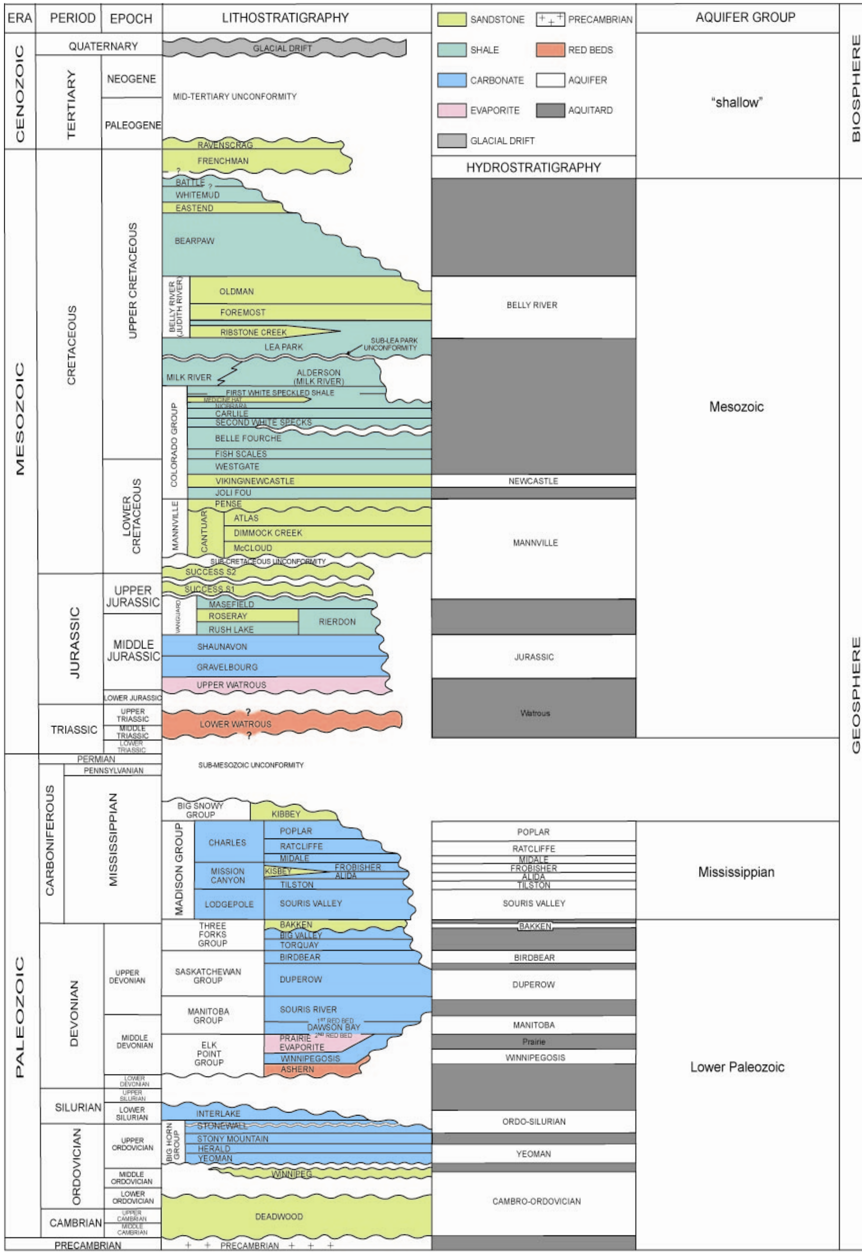
Subregional seals

Muderong Shale most important seal in the basin

Large overpressure may be found below Dingo Claystone

?

Williston Basin, Canada



Regional Seals

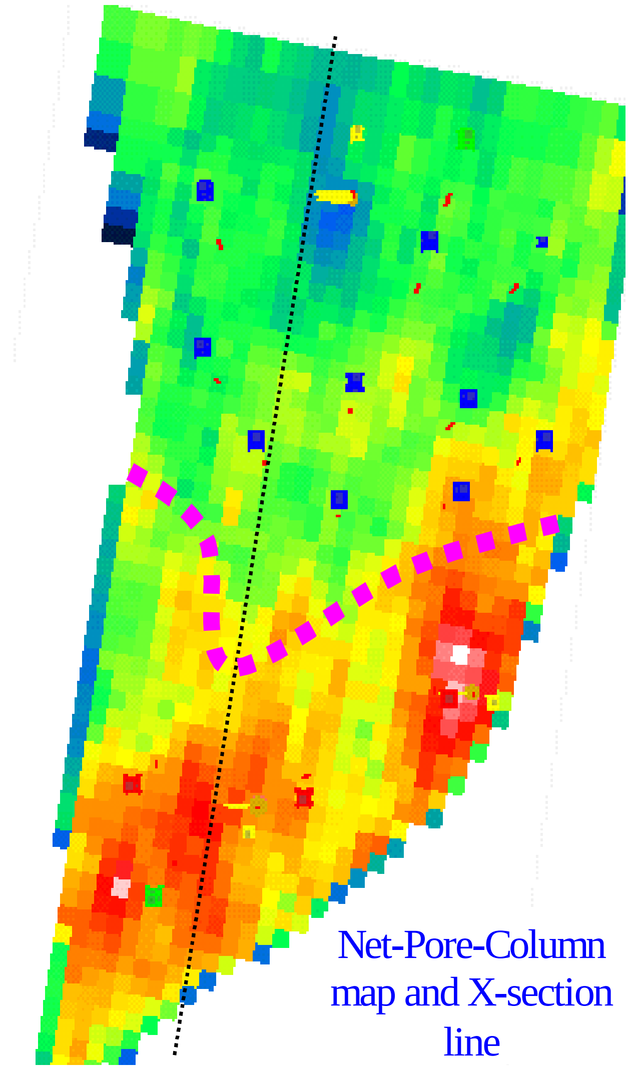
U & L Watrous –seals for Weyburn Midale oil

Prairie Evaporite

Khan and Rostron, 2004

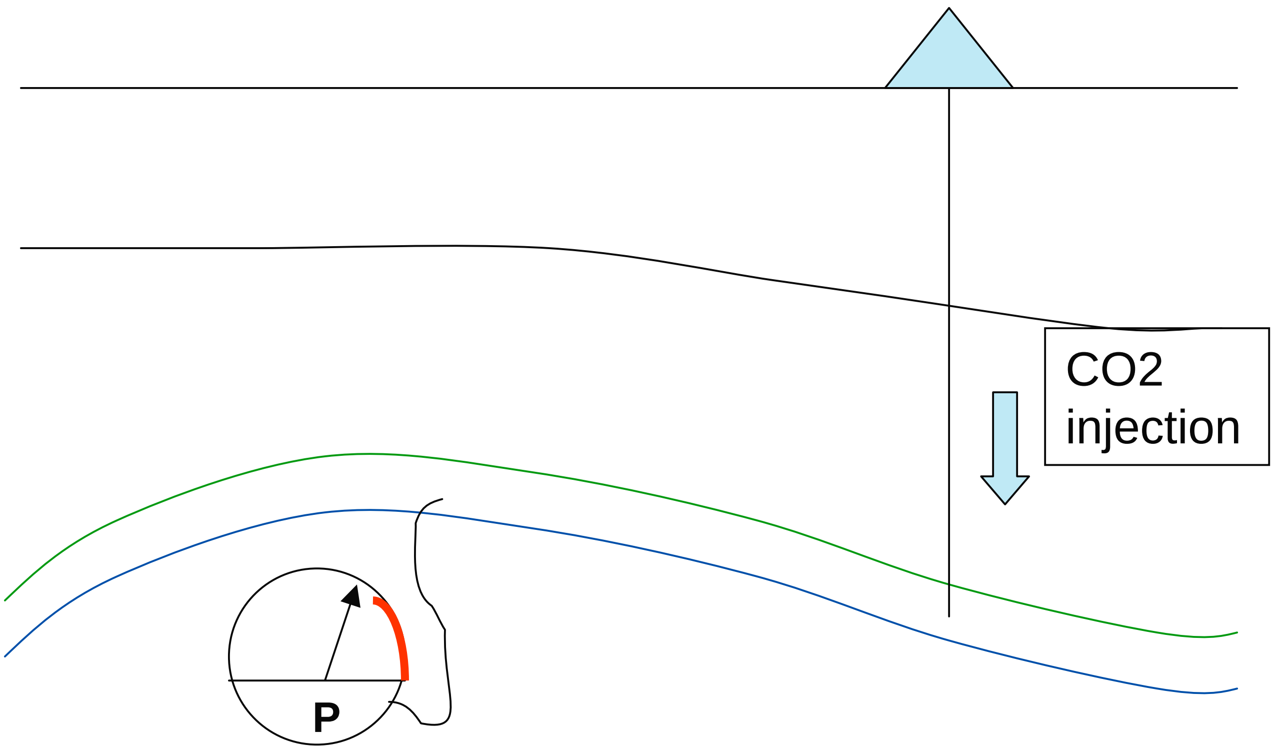
Screening - volumes

- Using map at base of regional seal, find attractive geometries with reservoir facies
- Test for adequate aquifer volume available for the program injection
- For example, scoping simulation for a fault block option found:
  - Injection without production is not feasible
  - Day 1 injection requires 8 injectors @5000 PSI WHP
  - Aquifer quality is expected to be poor and is a key uncertainty

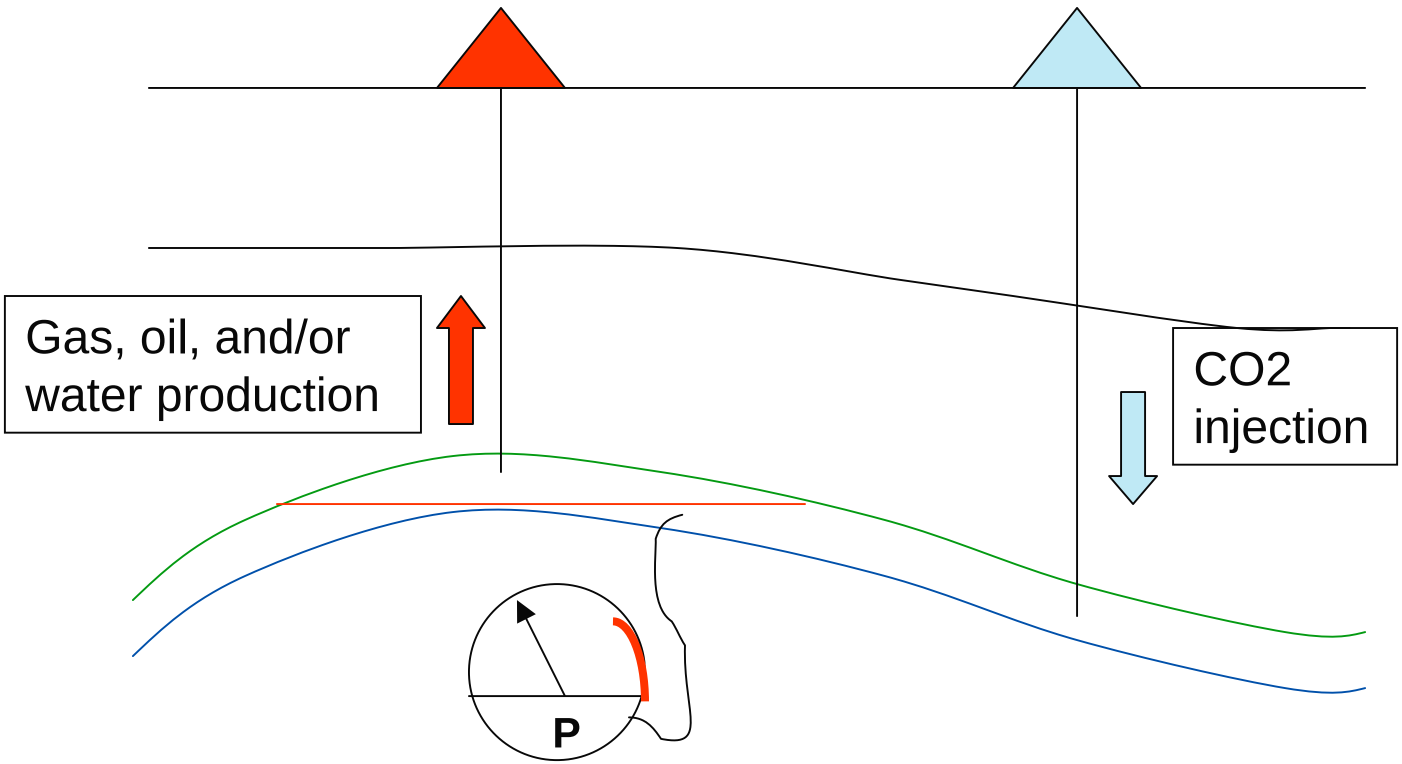


Net-Pore-Column map and X-section line

Aquifer volume needs to be large to keep pressures reasonable



Production adds potential capacity to aquifer solutions by providing voidage



Further screening

Further screening needs to address:

•All else being equal, closer to the source is better. Estimate pipeline costs and risks

•Estimates for the number of wells – fewer wells is better. Check if the wells interfere with each other, raising pressures and limiting injection locally

•Estimate the compression needed for injection – sites with near hydrostatic pressures are preferred

•Estimate impact and work requirements for dealing with existing wells. Fewer wells in the injection interval is better

•Determine the requirement for storing CO_2 in a separate phase until solution or solid storage is achieved

Evaluate and rank the portfolio of options

- Determine economic characteristics of the potential sites
- Estimate the remaining work to be done and the cost for that work in order to bring the sites to the decision point for final choice and regulatory approval
- Ensure, to the extent possible, that the site and storage process will qualify for whatever credits and financial incentives that may be available

Monitoring considerations in site selection

A monitoring program will be required for:

•Site permitting – regulatory approval process

•Verification of injected volumes for credits

•Hazard/leakage identification

•Possible injection operation improvements, realignment

Monitoring approaches

- Injection well pressure and injection rates are base measurements likely required in all cases
- Other requirements should be fit to the site and problem characteristics
- Monitoring requirements should be results oriented rather than process oriented
- No single geophysical or geological technique is likely to fit all cases

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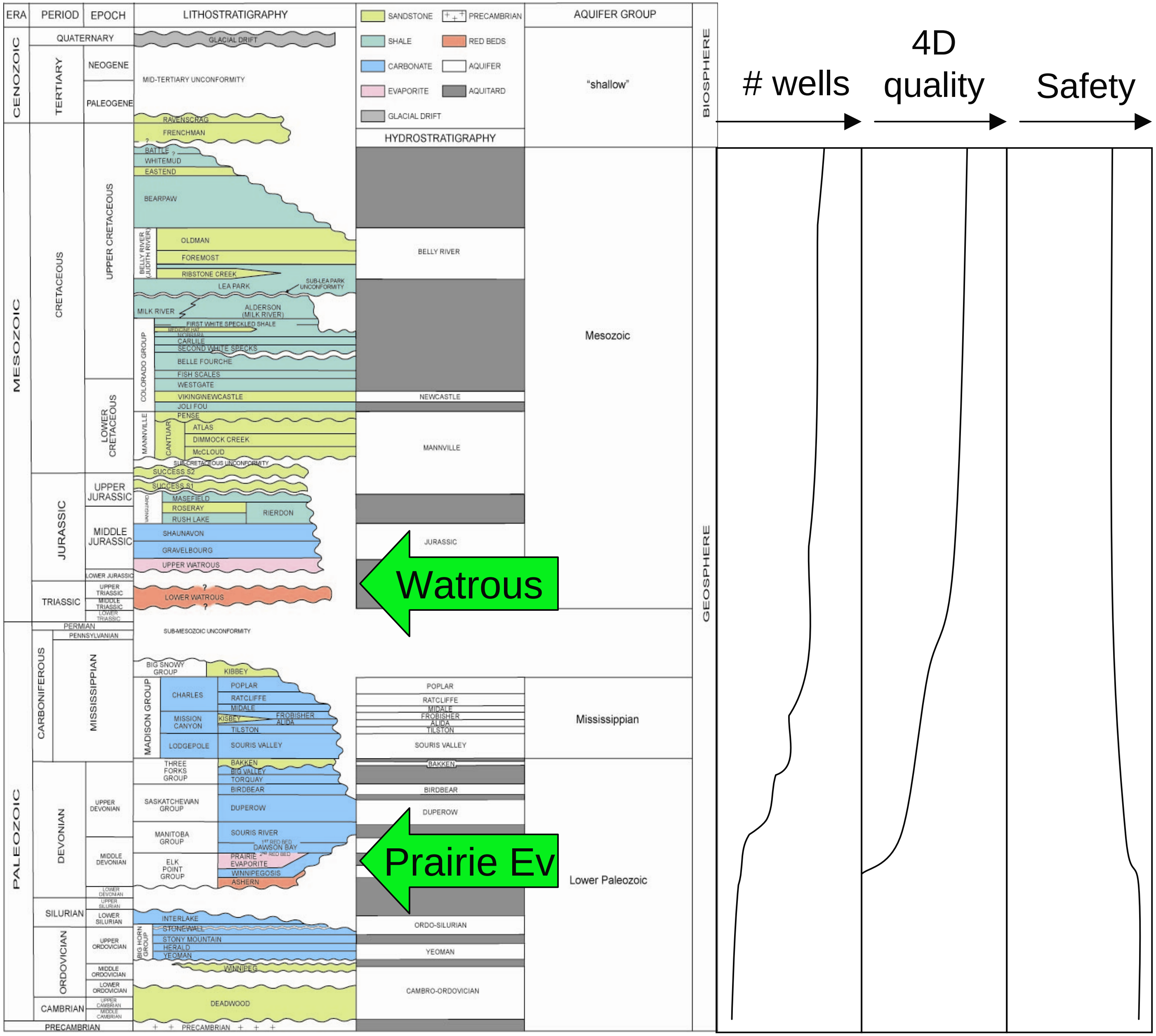
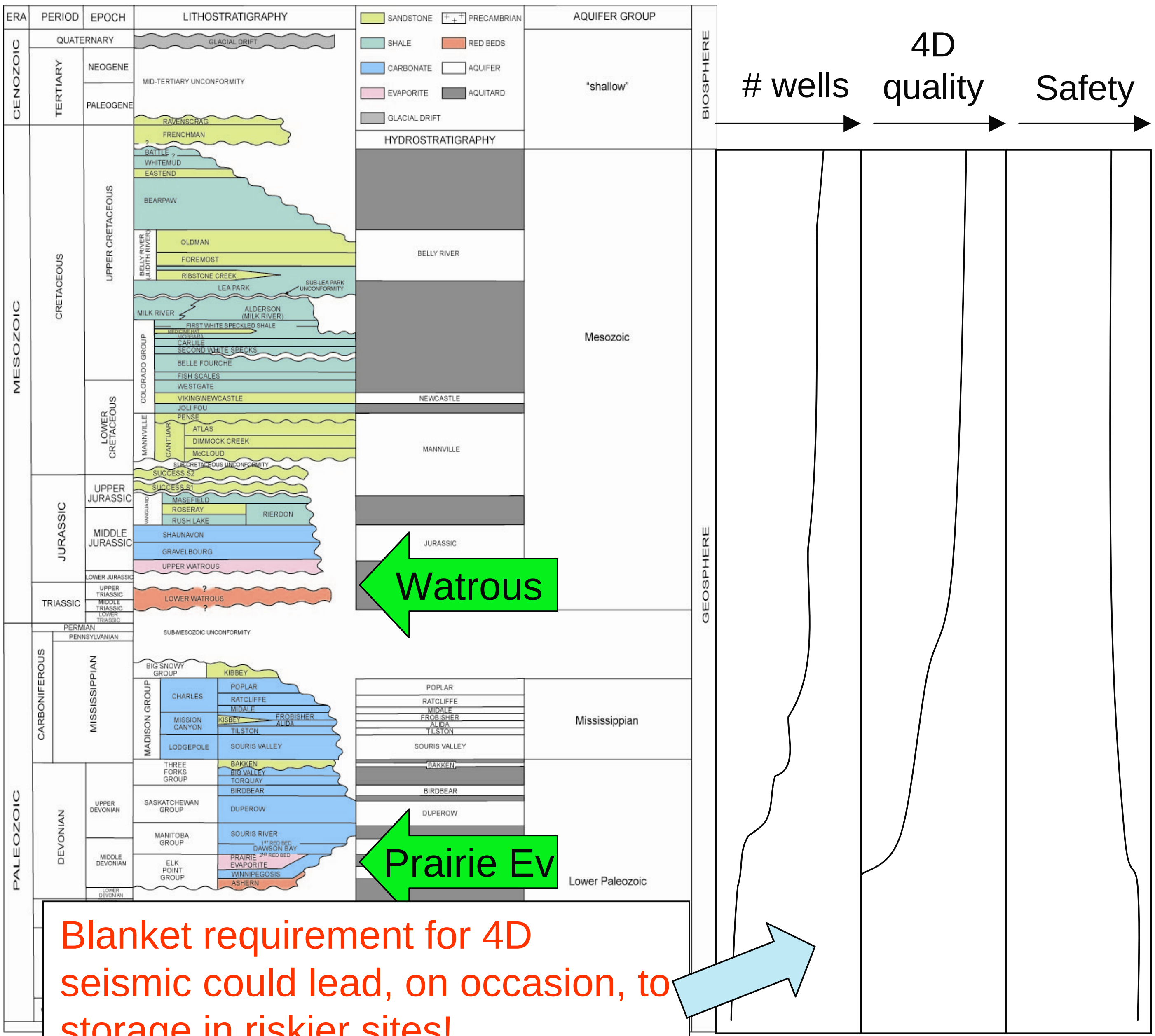
➢ In spite of success at Sleipner and Weyburn, and several proposals for other projects, 4D seismic should not be required for all cases

4D seismic and safety (leakage risk)



Khan and Rostron, 2004

4D seismic and safety (leakage risk)



Blanket requirement for 4D seismic could lead, on occasion, to storage in riskier sites!

Khan and Rostron, 2004

Conclusions

•Geological storage of large volumes of CO_2 is possible

•Screening for storage sites builds on current technologies in a straightforward way.

•Regulatory and economic constraints are important and must be considered from the start of the project

•The most viable sites that emerge from screening are then subject to

- further formal risk assessment and project design on the technical side
- negotiations with company management, regulators and the public in order to build consensus on the forward path to a successful storage project